The heterogeneity of MNC' subsidiaries and technology spillovers: explaining positive and negative effects in emerging economies

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Abstract: Conventional models of multinational corporation (MNC) related spillovers in host economies assume that they derive from the technological assets created at the headquarters. Subsidiaries' activities in the host economy are not given any role in this process. In this paper, drawing on recent advances in MNC literature, we propose an alternative model. In this alternative model the local innovative activity of subsidiaries plays a critical role in accounting for both the possibility of positive or negative effects. More specifically, we distinguish between three types of subsidiaries: 'competence creating', 'competence exploiting' and passive; and explore conceptually and empirically the spillover effects of each type. Our results confirm our predictions that, in less advanced contexts such as India, only creative subsidiaries have a positive effect on host country firms; that competence exploiting subsidiaries generate negative effects when domestic firms are more advanced; and passive subsidiaries have no effects. The implications for theory and policy are discussed.

Key words: Technological spillovers, MNCs, emerging economies, subsidiaries heterogeneity

JEL code: O3, O4 and O1

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1. Introduction

Research on spillover effects from FDI in host economies for years has been dominated by a particular view of the MNC based on the knowledge asset and the internalisation theory of the MNC. From Hymer (1976) and Caves (1974), to Haskel et al. (2002), Blomstrom and Kokko (2003) and Javorcik, (2004), four assumptions have underpinned the research: (1) that MNCs exist because they are able to develop, accumulate and take advantage of a unique set of technological assets, such as particular product innovations and superior management or marketing techniques; (2) that these unique technological assets are originated in the home country of the MNC, and transferred to subsidiaries via FDI, (3) that technology transfer takes place easily between MNC units, so assets and technology can be easily moved across different departments and branches within the MNC, or from headquarters to local subsidiaries; and (4) that the MNC is a tightly integrated organisation, with the behaviour of subsidiaries closely shaped by central strategies and decisions (Blomstrom and Kokko, 2003; Markusen, 1995; Hymer, 1976; Haskel et al., 2002; Driffield and Love, 2007). The combination of these conditions provides the basis for a *'pipeline model'* (Marin and Bell, 2006) in which spillovers of superior technology are supposed to be delivered from MNC parents, via subsidiaries, to domestic firms, but without local subsidiaries intervening in any important way.

In the face of weak empirical evidence (see Javorcik, 2004 for a discussion of the empirical literature and Crespo and Fontoura, 2007 for a recent survey), it has often been argued that the absence of spillovers is due to the limited capabilities of locally owned firms to absorb potential spillovers (Konings, 2001; Kokko, 1994; Girma, 2005) or the strategies of MNCs in terms of what is transferred to subsidiaries (Driffield and Love, 2007; Wang and Blomstrom, 1992). Subsidiaries are assumed to play no role in the process. Even in the absence of positive effects, it is still presumed that there is a 'knowledge pipeline' running from the MNC parent companies, via international technology transfer, to the subsidiaries, so creating at least a potential for spillover effects.

But recent theorising on MNCs in the management and international business (IB) literature questions this view.[1] First, this literature questions the idea that MNCs' ownership advantages emerge exclusively from the technological assets created by MNCs in the home country. It argues that technologically active subsidiaries, with their knowledge activities dispersed across diverse locations, are playing increasingly important roles in the process of advantage creation within MNCs (Cantwell 1995; Birkinshaw *et al*, 1998; Feinberg and Gupta, 2004). Second, the MNC literature questions whether the technological assets that sustain these advantages can be transferred easily, smoothly and at no cost across different branches of the MNC. Instead, technologically active subsidiaries are key in assuring that this technology transfer takes place effectively (Teece, 1977; Sulansky, 1996, Gupta and Govindarajan, 2000).

Accordingly, in this paper we propose a '*subsidiary-centred model'* of spillover effects, elements of which were described in an earlier work (Marin and Bell, 2006). In this model any significant spillover effects associated with MNC' operations, are likely to reflect differences in the quantity and nature of the technological activity of the subsidiaries in the host economy. In this paper we elaborate on this model drawing on recent MNC studies that distinguish between three types of subsidiaries: 'competence creating', 'competence exploiting' (Cantwell and Mudambi, 2005) and 'passive' or 'quiescent' subsidiaries (Taggart, 1998; Marin, 2006). We explore how heterogeneity across these types of subsidiaries relates to spillover effects in the host economy.

In line with common practice, we model FDI spillovers within the familiar production function framework. However, our empirical analysis improves on the recent literature in several ways. First, we include a novel methodological step in the main analysis to estimate the spillover effects of heterogeneity among subsidiaries. Second, we take account of some econometric problems rarely considered in earlier studies, which might have caused bias in previous results. In particular, we use the semi-parametric approach suggested by Levinsohn and Petrin (2003) designed to control for endogeneity in the determination of inputs. Third, as suggested by Javorcik (2004), we use clustered standard errors to correct

[1] We use IB and MNC interchangeably to describe this literature.

for the fact that measures of potential spillovers are industry specific while observations in the data set are at firm level. Thus, we avoid possible downward bias in the estimated standard errors and spurious findings. Fourth, we do not assume that all sectors have the same production function; instead, we allow the main coefficients to change by calculating a production function for each two-digit sector.

We estimate horizontal spillovers. The estimation uses data covering the period 1994-2002 from Prowess, a database provided by the Centre for Monitoring Indian Economy (CMIE). The sample is representative of manufacturing firms in India.

Our results are very interesting. Like many of the existing studies, we found MNC-related spillovers do not arise simply from FDI flows. Instead, the significance and positive/negative sign of these spillover effects are strongly associated with the intensity and nature of the technological activities of the subsidiaries in the host economy, which vary substantially in India. In particular, and in accord with our hypotheses, we found that significant positive spillovers only emerge in association with the activities of competence creating subsidiaries, that knowledge exploiting subsidiaries have a negative effect on the more advanced domestic firms; and that passive subsidiaries have no effects on the host economy. These results suggest, (i) that the knowledge asset model of the MNC is not adequate to explore the process of spillover effects in association with MNC operations, and (ii) that there seems to be enormous potential for exploring the effects of different aspects of subsidiaries' heterogeneity on spillover effects.

The paper is organised as follows. Section 2 discusses the background and develops our hypotheses about the association between MNC subsidiaries' knowledge activities, and spillover effects. Section 3 briefly discusses the context: FDI in India. Section 4 describes the data and the methodology. Section 5 analyses our results, and Section 6 concludes, with implications for theory and policy.

2 A Subsidiary-driven Model of Spillover Effects: Background and hypotheses

2.1 Background

The standard approach: Underlying view of the MNC

Since the mid 1980s a great deal of work has focused on FDI-related technological spillovers in host economies (e.g. Blomstrom and Person, 1983; Blomstrom, 1986; Haddad and Harrison, 1993; Blomstrom and Sjoholm, 1999; Haskel et al., 2002; Kathuria, 2002; Javorcik, 2004; Girma, 2005; Javorcik and Spatareanu, 2008; Chang and Xu, 2008). In most of this work however, ideas about the workings of the process on the 'supply side' have remained largely the same as in the pioneering studies of Caves (1974) and Findlay (1978). Spillovers from MNCs to domestic firms are presumed to be exclusively associated with the technological assets of the MNCs created in their headquarters. The technological activities of the subsidiaries in the host economy are not given credit for playing a role in this process. Even in the absence of spillover effects, the role of subsidiaries' technological activities is rarely analysed.[2].

This view is based on early MNC theories which assumed that subsidiaries' knowledge activities were adaptive adjuncts to the transfer of technology from parents, especially in the case of MNC affiliates in developing countries (see, e.g. Hymer, 1976; Caves, 1974; Rugman, 1981; Lall, 1979). These theories reflected the reality of most MNCs at the early stages of internationalisation when this device was typically used to enable expansion worldwide to exploit the monopolistic advantages gained in the domestic market – based on what Perlmutter (1965) calls an ethnocentric model (Hymer, 1976; Dunning, 1977). In this model, subsidiaries were typically managed by home country personnel using vertical division of labour; upstream activities in the value-chain were conducted at the centre, and downstream ones, by the periphery. In this model, foreign subsidiaries inevitably played an operational, rather than a strategic or innovative role, and were tightly controlled by managers in the home country of the MNC.

This view was summarised by Rugman (1981), one of the leading contributors to the early development of a MNC theory: 'the subsidiaries exist primarily as extensions of the parent firm

[2] Three exceptions are the studies by Todo and Miyamoto (2002) for Indonesia, Castellani and Zanfei (2005) for Italy and Marin and Bell (2006) for Argentina.

and their business is to safeguard the market and the MNE in the host nation … The role of the subsidiary is supportive to the R&D function of the parent and it cannot be an innovator' Rugman (1981: 135-137).

Modern views of the MNC: Incorporating active subsidiaries

Things have changed substantially since the late 1970s, and the MNC literature, has by and large, reflected those changes. The diffusion of new technologies and organisational arrangements, and deep changes in world competition, have seriously affected the possibilities for international firms to look for, monitor, create and exploit advantages. Managers of MNCs nowadays enjoy an unprecedented degree of flexibility in moving production around, and in transferring know-how and knowledge from one location to another (Kogut, 2002). They therefore are more aware of and often make use of the knowledge that exists in host economies (Cantwell, 1995, 2001; Kogut, 2002; Hedlund, 1986; Dunning, 1994; Cantwell and Sanna-Randaccio, 1993). In the words of Hedlund (1986) international business is now about 'actively seeking advantages originating in the global spread of the firm' rather than just exploiting centrally created technological assets. As a consequence, as Cantwell (2001) argues, MNCs have moved from being only 'technology creators' to being also 'technology organisers' within their networked corporate structures.

The earlier models of MNCs as centrally directed, closely integrated, hierarchical organisations with passive subsidiaries, have therefore lost relevance, and more flexible approaches have gained in importance (Ghoshal and Bartlett, 1990). These recognise varying forms of organisational flexibility and internal *heterogeneity in the roles of technological activities in subsidiaries* (see for instance, Ghoshal and Bartlett, 1990; Birkinshaw and Hood, 1998; Pearce, 1999; Cantwell and Janne, 1999; Kuemmerle, 1999; Papanastassiou and Pearce, 1999; Zander, 1999; Kumar, 2001; von Zedwitz aandGassman, 2002; Cantwelll and Iammarino, 2003). One example of these more flexible approaches is the network-based model of the MNC introduced by Ghoshal and Bartlett (1990). This model conceptualises the MNC as a differentiated network of dispersed operations, with a configuration of activities and resources not fully controlled by hierarchical decisions made in the headquarters (Prahalad and Doz, 1981). Furthermore, within such a network each

unit (subsidiary) is recognised as being unique and is given a potentially important role in the process of knowledge asset (advantage) creation within the MNC.

Identifying different roles for subsidiaries' technological activities in host countries

Alongside these changes the MNC literature has begun to focus on subsidiaries as a separate unit of analysis with several studies highlighting several types of heterogeneities in their roles, and developing a number of typologies emphasising different aspects of this heterogeneity.

One typology that has become very popular distinguishes between two possible roles played by the dispersed technological activities of subsidiaries: supporting the exploitation of existing MNC technological assets in host country contexts; and the creation of new knowledge assets for the MNC. In Cantwell and Mudambi's (2005) words, subsidiaries can have 'competence exploiting' or 'competence creating' roles.[3] Competence exploiting subsidiaries play more of an 'assembly' role; competence creating subsidiaries play a more creative role (Cantwell and Mudambi, 2005).

However, not all subsidiaries will have sufficient competence to explore or exploit technological assets, and this has been acknowledged in the literature on subsidiaries. This strand of the literature points to the existence of what can be considered a third type of subsidiary: the 'quiescent' or passive subsidiary[4] (Taggart, 1998; Nohria and Ghosal, 1994; Marin 2006). Passive or quiescent subsidiaries have low levels of functional scope in the host country, including research and development (R&D), and low levels of integration in

[3] Kuemmerle (1996) refers to 'home-base exploiting' or 'home-base augmenting' FDI. This terminology however is more consistent with early conceptualisations of the MNC which see activities in subsidiaries as being exclusively driven by MNC motivations and strategies and are less concerned with subsidiary level strategies, as in the more modern flexible approaches to the MNC. Since it is in the spirit of this study to explore the implications of more modern/flexible approaches to FDI-related spillovers, we adopt the approach proposed by Cantwell and Mudambi (2005). Other authors who have developed similar concepts to those used in Cantwell and Mudambi (2005), which are more consistent with the network model of the MNC, include Narula and Zanfei (2004) and Criscuolo et al. (2005) who talk about 'asset exploiting' and 'asset-augmenting' forms of dispersed innovative activity.

[4] Note that this is not the same as the passive subsidiaries implicit in the more conventional views of the MNC discussed earlier, in which subsidiaries are not directly conceptualised as being different from the parent MNC. In this case, subsidiaries are envisaged as different, but identified as inactive (passive) parts of the MNC network.

the technological and other resources of the corporation. Therefore, they are unlikely to have the capacity to either explore or exploit new knowledge in the host economy. Although they have received far less attention in the literature (see e.g., Jarillo and Martinez, 1990), these types of subsidiaries might be quite important in less advanced contexts where levels of competition and the technological complexity of demand are typically relatively low – i.e. where local markets are relatively 'easy' and subsidiaries can exist with very low investment in either the exploitation or the development of new technologies.[5] We consider this type, therefore, a potentially relevant group in our analysis in succeeding sections of the association between subsidiary types and spillover effects.

2.2 Incorporating heterogeneous subsidiaries in models of spillovers: Our hypotheses

We believe that this diversity of roles across subsidiaries types is likely to have important implications for spillover effects. In particular, we expect that 'competence creating' subsidiaries engaged in exploration activities, will be most likely to generate positive spillovers effects in less advanced contexts. This is because the knowledge resources that could potentially 'leak' to domestic firms, in association with their activities, is superior or more valuable. Exploration activities include things such as 'search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation' (March, 1991: 71)*;* and these kinds of activities, together with the capabilities associated with them are much less frequent in less advanced contexts (Kim, 1997; Bell and Pavitt; 1997).[6] The diffusion of these capabilities thus, is much more likely to have a significant impact on innovation and productivity growth in domestic firms in less advanced contexts, and particularly if, as

[5] The empirical analysis of the variance in subsidiaries' technological activity in India, reported in Section 4, confirms this assumption: 50% of subsidiaries in India do not invest in R&D or Royalties, and so can be classified as technologically passive.

[6] The literature on innovation in firms in industrialising countries is quite clear about the difficulties for firms in less advanced contexts to be innovative or to develop innovations that are close to the technological frontier (Kim, 1997; Bell and Pavitt; 1997). They often are able to acquire or develop operative capabilities (i.e. the capabilities to operate existing technologies at given efficiency levels), imitative capabilities (i.e. the capabilities to reproduce existing technologies), and adaptative capabilities (i.e. the capabilities to develop incremental adaptations, improvements and redesign), all of which can be classified as exploitative capabilities. However, they find it much more difficult to develop innovative or creative capabilities (i.e. the capabilities to produce more substantial developments in the technology or to generate innovations at the frontier). An indication of this fact is provided by the following figures: in 2002 only 12% of world patents were issued to developing country firms and developing countries accounted for less than 10% of total world R&D expenditure, whiles these countries explained 89% of the total world population.

suggested in the literature, the more creative subsidiaries are also the most well embedded locally, which implies that they would have channels appropriate to diffuse their superior knowledge resources to domestic firms[7] (Cantwell and Mudambi, 2005).

'Competence exploiting' subsidiaries, on the other hand, have less to offer. They may have superior technology embedded in machinery, tools and products, but have fewer innovative capacities and practices. They will be less likely, therefore, to induce productivity increases in domestic firms associated with flows of knowledge (or capacities) otherwise unavailable in the host economy. Also, it is likely that these types of subsidiaries could exert a negative effect on the domestic firms competing with them because competence exploiting subsidiaries, by definition, are dedicated to exploiting the technological resources created elsewhere in their MNC network. They do not incur the costs necessary to develop these resources and, therefore, are better able to reduce cost and prices below the levels of competing domestic firms, thereby diverting demand away from domestic firms and pushing up their costs of production (Aitken and Harrison, 1999).[8] This negative effect is less likely to emerge in the case of competence creating subsidiaries because they are more likely to incur costs of their own in trying to source/develop knowledge locally, and less likely to be direct competitors of domestic firms.

Finally, in our view passive subsidiaries are unlikely to have any (positive or negative) effects on domestic firms because they have nothing to offer in the way of superior technological resources or competitive pressure. They will not be creative and will be unable to absorb the superior technology that, in theory, would be available to them from

[7] The superior or more valuable capabilities that may diffuse to domestic firms through the 'competence creating' activities of subsidiaries in the host economy include: a) the organisational practices and routines conducive to innovation at individual and team level, that can be 'demonstrated' to domestic firms; 2) the technical knowledge necessary to innovate in particular activities, which is embedded in skilled workers who may take up positions in host country companies; 3) the knowledge embedded in the superior products/services created by the subsidiaries which can be 'copied' by domestic firms.

[8] They are also more likely than 'competence creating' subsidiaries to become actual competitors of domestic firms, which increases the possibilities that these effects take place. This is because they are more likely than 'competence creating' subsidiaries to share 'resource similarity' and 'market commonality' with domestic firms (Chen, 1996).Competence exploiting subsidiaries are likely to have resource similarity with domestic firms in less advanced contexts because they will both be oriented more to exploitation than to exploration (see note 7). They are more likely, therefore, to adopt similar strategies, serve similar types of markets and become direct competitors (Chang and Xu, 2008; Teece et al., 1997).

within their corporations (Teece, 1977; Szulansky, 1996; Gupta and Govindarajan, 2001). Thus, they are unlikely to have anything superior to diffuse to domestic firms and to affect their productivity or innovative capacity. At the same time, because of their inability to absorb the superior technological resources that are available to them, they will also be unlikely to be able to exert competitive pressure on domestic firms via cost reductions.

Based on the above we propose the following hypotheses:

Hypothesis 1: *Competence creating subsidiaries are more likely than competence exploiting or passive subsidiaries to generate positive spillover effects because they are more likely to own and, therefore, to diffuse, technological capabilities that are valuable relative to those that exist in less advanced host countries..*

Hypothesis 2: *Competence exploiting subsidiaries are more likely than competence creating and passive subsidiaries to have a negative effect on domestic firms because they are less likely to spread superior knowledge resources and, at the same time, are able to exploit the resources available in their MNC network to reduce costs and redirect demand away from domestic firms, pushing up their costs.*

Hypothesis 3: *Passive subsidiaries are likely to have no effect on domestic firms because they will likely be unable to diffuse superior existing or new knowledge or exert competitive pressures on them.*

In a recent UK study, Driffield and Love (2007) postulated what might be seen as an contrary hypothesis to ours in relation to the association between spillovers and the exploitation vs exploration activities of MNCs. Focusing more on MNC motivations and less on subsidiaries' heterogeneity, they distinguish FDI in two types: technology sourcing and technology exploiting investment. They propose that technology sourcing FDI will be less likely than technology exploiting FDI to generate spillovers because, in their view, FDI motivated by technology sourcing, which typically is conducted by 'MNCs without advantages' (Fosfuri and Motta, 1999) will have less to offer. Empirically, they distinguish

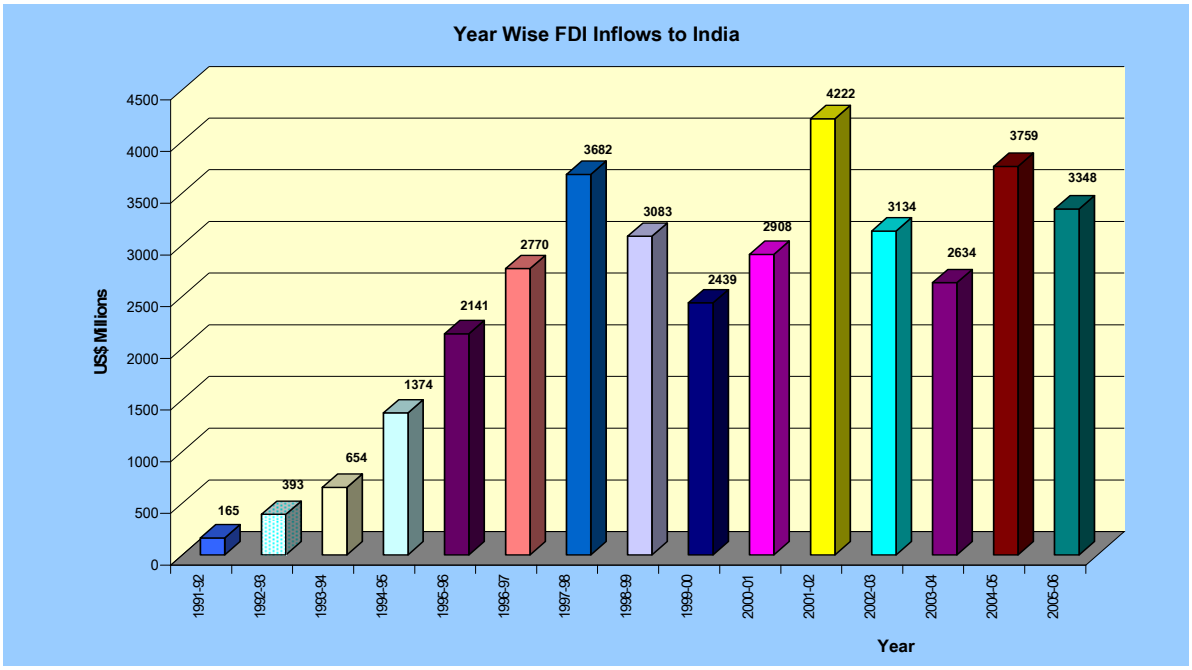
between technology sourcing and technology exploiting FDI using R&D intensity differentials for the home and host countries per industry. They assume that if R&D intensity is higher in the host country relative to the home country, FDI will be directed towards sourcing technology in the host country, and that if R&D intensity is lower in the host country relative to the home country, the reverse will be true. Their empirical analysis of UK FDI confirms their hypothesis. In our view this study has two problems which question its relevance here.

The first is that it focuses on heterogeneity in FDI motivations rather than heterogeneity across subsidiaries and its methodological implications. It is not consistent, therefore, with the more flexible approaches to MNCs discussed above, which recognise that subsidiaries' roles can be driven by issues such as managerial initiative and discretion and, therefore, can evolve independently of the MNC's original motivations to engage in FDI (Birkinshaw and Hood, 1998). In line with these more flexible approaches, we focus on subsidiaries' rather than on FDI motivations.

The second problem relates to the assumption that MNCs engaged in technology sourcing have less superior knowledge to offer. This assumption probably applies to MNCs from less advanced contexts (see, e.g., Buckley et al., 2007). However, most foreign R&D, and indeed FDI, is carried out by MNCs from advanced contexts, and the evidence shows that the more advanced and complex the MNC the more likely it will conduct R&D abroad as a way to increase its knowledge assets (see, e.g., Cantwell and Mudambi, 2005; Cantwell and Janne, 1999; Zejan, 1990; Almeida and Phene, 2004; Hakanson, 1992). It would be likely, therefore, that these MNCs would have substantial superior capabilities and resources that would spill over to host country firms. This evidence, in addition to the focus on less advanced contexts in our case, justifies our expectation of positive effects associated with subsidiaries' knowledge creating activities, which contrasts to Driffield and Love's (2007) assumptions for the UK.

3. The Context: FDI Inflows in India

Until 1990, the Indian economy was characterised by severe controls and regulations on foreign capital and ownership. During the regulated regime, foreign investment was not considered as a means to obtain technological knowledge that was unavailable in India. The preferred mechanism for acquiring knowledge during this period was through imports of capital goods, and licensing agreements (Kumar, 1994). However, the reality was that the dirigiste regime in India was a major stumbling block to the acquisition of much needed modern technology. The unprecedented economic crisis that occurred in 1991, forced India's policy makers to make transformations to this highly regulated regime and the liberalised regime since 1991 dismantled the industrial licensing system and removed restrictions on foreign equity participation. Since then, the Indian economy has witnessed a surge in FDI. However, in the initial years of reforms these investments were mainly portfolio investments, but FDI did increase, reaching an all-time high of US$4,222 million during the financial year 2001-02. Figure 1 depicts the rise in inflows to 1997-98, followed by some stagnation and then an increase in inflows to 2001-02. However, the surge in FDI inflows during the 1990s cannot be attributed entirely to the adoption of liberal FDI policies. According to Kumar (2005), it was also due to the rise in global FDI outflows that occurred during these years.



Source: SIA Newsletter (various issues) http://dipp.nic.in

The composition of FDI also underwent drastic changes in the 1990s. In the regulated period, plantation and mining accounted for nearly 80% of total FDI. However, its share saw a sharp decline since (from 9% in 1980 to 2% in 1997) when FDI became more focused on the manufacturing sectors. By the end of 1990, manufacturing accounted for 85% of the total FDI stock. In the pre-reform period, the major source of foreign capital in India came from the UK and other European countries. With the introduction of reforms there was a shift in FDI inflows, from the UK and Europe to the USA. Currently the main investors are the USA, followed by Japan, the Netherlands and the UK. The USA contributed about 18% of total FDI inflows in the period 1991-2005. The emergence of the USA as the main source of FDI into India could be due to two factors: (i) the USA is India's largest trading partner; and (ii) there are substantial numbers of Indians living in the US.

4. Methodology

4.1 The data

The empirical analysis reported here uses information provided by Prowess which is a data base provided by the CMIE containing information on 9,800 firms registered with the Bombay Stock Exchange. We use data on firms in the manufacturing sector (Sectors 15 to 36 based on the NIC classification). Our original sample, representative of the population of manufacturing firms in the country was 4,900 firms for the period 1994-2002. This was reduced to 2,000 due to missing values. Twelve per cent of the firms in this sample are foreign subsidiaries.

The data base provides basic economic firm level data such as firm size, age, added value, exports, imports, sales, employment, etc., which permits the computation of various performance indicators (e.g. productivity levels, growth rates). In addition, it provides information on technological activities at firm level and this enables the computation of

several measures of technological behaviour for both MNC subsidiaries and domestic firms, as explained below.

4.2 Identifying types of subsidiaries

We use four indicators for subsidiaries' technological activity available from the data base, to identify the three types of subsidiaries discussed in the previous section:

I-	*Intensity of expenditure on R&D*
II-	*Skills intensity*
III	*Intensity of royalty payments*
IV	*Intensity of capital goods imports*

R&D expenditure measures the systematic efforts undertaken by firms in order to increase the stock of knowledge, and the use of this stock of knowledge to devise new applications. Although not all ***R&D*** is dedicated to creative activities it is generally accepted that this is a good indicator of the creative efforts of firms.

Skills intensity captures different intensities of qualified human resources employed by firms, which in principle, are capable of monitoring, incorporating and developing new technological knowledge. This indicator complements R&D expenditure, because it captures the resources potentially capable of innovative activity.

Since we do not have information on the levels of education of the work force we use added value plus wages to calculate a proxy for skills. Following Aggarwal (2002), we measure *skills intensity* as value added per unit of the wage bill.

Royalties are usage-based payments made by one party (the licensee) to another (the licensor) for ongoing use of an asset, or intellectual property. They are a good indicator of the efforts undertaken by firms to incorporate technological knowledge produced by other firms or institutions, which is not embodied in any kind of equipment or instrument.

Intensity of capital goods imports is a measure of the firm's efforts expended on introducing new technological knowledge embodied in equipment or machineries.

Table 1 shows how subsidiaries distribute with respect to these indicators..

Table 1: Technological activity of subsidiaries in India, summary of descriptive statistics.

Indicators[1]	R&D Intensity (%)	Skills Intensity (%)	Royalties Intensity (%)	Imports Capital Goods Intensity (%)
Mean	0.5%	50%	0.7%	2.7%
Std. Dev.	2.5%	2.22	2.2%	8.7%
Distribution of firms				
1%	0.0%	0.0%	0.0%	0.0%
5%	0.0%	0.0%	0.0%	0.0%
10%	0.0%	0.1%	0.0%	0.0%
25%	0.0%	0.5%	0.0%	0.0%
50%	0.0%	2.8%	0.0%	0.2%
75%	0.4%	14.9%	0.5%	1.5%
90%	1.2%	70.6%	2.2%	5.8%
95%	2.0%	220.8%	4.0%	12.1%
99%	6.3%	1,112.4%	9.3%	50.1%

1 All indicators are intensities; R&D, royalties and imports of capital goods with respect to total sales, and skills with respect to wages.

Based on these measures we identify the three types of subsidiaries discussed above, as follow:

1. ***competence creating*** subsidiaries, defined here as the subsidiaries that invest heavily in R&D (see, e.g. Cantwell and Mudambi, 2005) which have highly skilled personnel - in both cases higher than the top quartile;
2. ***competence exploiting*** subsidiaries, defined as subsidiaries that invest in royalties and import of capital goods and have skilled (more than the mean) personnel. However,

their level of R&D investment is less than the top quartile, which, in this case, equates with no investment in R&D (see Table 1 above);

3. The rest are ***passive***.

3.4 Estimating spillover effects

Our estimation of spillover effects involves two steps. In the first step, we calculate the production functions per sector to obtain measures of total factor productivity (TFP). In the second, we relate TFP to proxies for FDI participation.

First step

We use two approaches to estimate TFP:

(1) A log-linear transformation of a Cobb-Douglas production function:

$$\ln Y^{d}_{ijt} = \alpha + \beta_1 \ln K^{d}_{ijt} + \beta_2 \ln L^{d}_{ijt} + \beta_3 \ln M^{d}_{ijt} + \varepsilon_{ijt} \qquad (1)$$

where Y^{d}_{ijt} denotes the real output of firm *i*, operating in sector *j*, at time *t*; *d* denotes domestic firms, K^{d}_{ijt} is the value of fixed assets; L^{d}_{ijt} is expressed as efficiency units, calculated by dividing salaries and wages at firm level by the average wage rate of each firm's industry[9] and M^{d}_{ijt} is the value of materials. Nominal values are deflated using wholesale prices per industry obtained from the Central Statistical Organization (India).

(2) The semi-parametric approach suggested by Levinsohn and Petrin (2003), which corrects for endogeneity in the determination of inputs. This method allows for firm-specific productivity differences that exhibit idiosyncratic changes over time and, thus,

[9] Prowess does not provide number of employees at firm level. We used information on wages and salaries to calculate man days of work for each firm. Man days at firm level are calculated using the formula: No. of mandays per firm = salaries and wages/average wage rate. We obtained the average wage rate from Annual Survey of Industries (ASI) data, which provide information on total emoluments as well as total man days for relevant industry groups. At the time of this study, ASI data were available up to 2001; therefore, we had to extrapolate values for the year 2002. We obtained the average wage rate by dividing total emoluments by total man days (Average wage rate = total emoluments/total man days.

addresses the simultaneity bias between productivity shocks and input choices (for a discussion see Lenvinsohn and Petrin, 2003).

Second step

In the second step we relate the two measures of TFP to proxies for foreign participation in the same five-digit industry.

$$\Delta \ln TFP^{d}{}_{ijT} = \alpha_0 + \alpha_1 \Delta FDIpart_{jt} + \alpha_3 \Delta Concentration_{jt} + \alpha_4 \Delta \mathrm{Im}\, ports$$
$$+ \alpha_5 Age_{ij} + \alpha_6 Age_{ij}{}^2 + I_j + T_t + \mu_{it}$$

FDI measures the scale of the MNC's presence in each sub-industry *j* and is introduced to capture spillover effects. It is calculated as the share of total employment/capital in the 5-digit sub-industry *j* that is accounted by the employment/capital of foreign owned firms in that sub-industry. Very often studies on spillover effects aggregated data at 2 digits (divisions). We work with FDI participation at 5 digits (subclasses). This provides greater variability and increases the possibility of identifying the desired effects. We use two measures of FDI presence per industry: employment and capital.

Since we are interested in exploring the differential spillover effects of different types of subsidiaries, in addition to the standard measure of FDI participation, which includes the share of employment and capital of all subsidiaries, we calculated a measure of FDI participation for each type of subsidiary. We calculated measures for competencies creating subsidiaries, competencies exploiting subsidiaries and passive subsidiaries.

I and *T* are industry and time dummies, and *Concentration*, *Imports* and *Age* are control variables.

To increase our ability to isolate the effect of FDI on productivity increases in domestic firms, we introduce two types of control variables.

- two variables reflecting changes in competition: changes in industry *Concentration* and *Import* penetration. These variables are designed to capture changes in the unobservable variables that affect competition and which might have promoted greater efficiency in the domestic industry.[10]
- *Age* and *Age square* to control for the potential effect of time on the total productivity growth of domestic firms.

Several other aspects of the estimation methods merit further comment. First, by using plant level specification and modelling in first differences, we control for fixed differences in productivity levels across firms and industries which could affect the level of foreign investment. We thus address the identification problem highlighted by Aitken and Harrison (1999).[11] Second, this specification and the inclusion of industry and time dummies corrects for the omission of other unobservable variables that might undermine the relationship between FDI and productivity growth of domestic firms. In particular:

- the use of first differences removes plant-specific, industry and regional fixed effects such as firms' heterogeneous long-term strategies, and differences in the regional infrastructure and/or technological opportunity of industries;[12]
- the use of industry dummies removes the fixed characteristics of domestic firms that belong to particular industries;
- the use of year dummies controls for economic-wide shocks

These controls are important in this analysis because industry effects are often seen as having the potential to affect spillovers from FDI.

[10] This is important because, as noted earlier, during the period analysed important pro-market reforms were introduced and developed in India.

[11] However, we cannot rule out the possibility of spurious correlation if there are industry characteristics that change over time and affect the pattern of FDI.

[12] This also controls for other factors that even when they are not fixed over time might be roughly constant over a 4 year period, such as level of education or regional policies.

Third, to take account of potential correlation between the error terms for firms in the same industry, we clustered standard errors in industry-year combinations.

Table 2 presents the summary statistic for the variables in the two steps.

Table 2: Summary statistics

Variables	Observations	Mean	Std dev..
Firm-specific variables			
Levels			
Output	17,402	181	1,907
Fixed Capital	17,402	75	575
Labour	17,402	34	183
Materials	17,402	112	593
Age	17,402	20	18
First Differences (ln)			
TFP (OLS)	12,784	-0.06	0.60
TFP (Levinsohn-Petrin)	12,784	-0.08	0.61
Industry Specific- Variables			
First Differences			
Horizontal all subsidiaries (employment)	318	-0.0015	0.0484
Horizontal all subsidiaries (capital)	318	-0.0011	0.0718
Horizontal technologically active subsidiaries (employment)	318	0.0013	0.0602
Horizontal technologically active subsidiaries (capital)	318	0.0008	0.0498
Horizontal technologically passive (employment)	318	-0.0015	0.0721
Horizontal technologically passive (capital)	318	-0.0007	0.0878
Horizontal competence creating (employment)	318	0.0017	0.0908
Horizontal competence creating (capital)	318	0.0014	0.0878
Horizontal competence exploiting (employment)	318	-0.0007	0.0650
Horizontal competence exploiting (capital)	318	-0.0013	0.0713
Concentration	318	-0.0026	0.0907
Imports	318	-0.0230	0.1072

5. Results

The subsidiary vs the pipeline models of FDI-related spillovers

The results of the first empirical estimation (columns 1 and 2 in Table 3) are derived from a specification similar to that used in much of the early work on spillover effects, in which FDI is expected to generate spillover effects without differentiating among subsidiaries. The coefficients of the FDI variable are not significant. Thus, similar to most existing

studies we find no evidence of technological spillovers from FDI in India, to domestic firms in the same 5-digit industries as the subsidiaries (see Crespo and Fontoura, 2007 for a recent survey of the empirical literature). We conclude therefore that, as in other situations (especially in industrialising economies), the process of international knowledge diffusion via FDI does not seem to have delivered the spillover effects expected by the pipeline model to domestic firms in India .

Table 3: Spillovers in the pipeline and subsidiary driven models – Quantitative differences across subsidiaries

Independent Variables	***Pipeline Model***		***Subsidiary Driven Model***	
	(1) FDI part in labour	(2) FDI part in capital	(3) FDI part in labour	(4) FDI part in capital
Spillover effects				
Δ FDI All types of subsidiaries	0.08	0.063		
	(0.44)	(0.6)		
Δ FDI competence creating subsidiaries			0.20	0.25
			(3.03)***	(3.47)***
Δ FDI competence exploiting subsidiaries			-0.06	0.045
			(-0.44)	(0.31)
Δ FDI technologically passive subsidiaries			0.14	0.11
			(0.94)	(1.72)
Control variables				
Age	-0.0029	-0.0029	-0.003	-0.003
	(-4.14)***	(-4.07)***	(-4.12)***	(-4.11)***
Age squared	0.000028	0.000028	0.000028	0.000028
	(3.42)***	(3.36)***	(3.39)***	(3.360***
Δ Concentration	-0.075	-0.07	-0.067	-0.062
	(-0.69)	(-0.65)	(-0.62)	(-0.57)
Δ Imports	-0.10	-0.09	-0.09	-0.09
	(-2.04)*	(-2.04)*	(-2.07)*	(-2.07)*
No. of observations	12,699	12,699	12,699	12,699
R-squared	0.012	0.02	0.021	0.022

1. The dependent variable is the change in TFP (expressed as a natural logarithm) of an Indian firm *i* at time *t*, derived from a sector specific production functions estimated using the Levinsohn-Petrin approach. All specifications include a constant, year and industry fixed effect. Standard errors corrected for clustering for industry-year combinations, are reported in parentheses. * denotes significance at 10% level, ** at the 5% level, *** at the 1% level.
2. Here we report only the results based on Levinsohn and Petrin, results obtained with ordinary least squares (OLS) are very similar, the sign and significance are the same. They are available from the authors on request.

3. Competence creating subsidiaries are those subsidiaries that invest heavily in R&D and have highly skilled personnel, in both cases higher than the top quartile. Competence Exploiting are the subsidiaries that invest in royalties and in imports of capital goods, and have highly skilled personnel, but do not invest in R&D. The rest are passive subsidiaries.
4. Columns (1) and (3) report the results obtained using ΔFDI participation in labour at 5-digit industry level, and columns (2) and (4) report the results obtained using ΔFDI participation in capital.

We now turn to spillovers in the 'subsidiary driven' model. In the discussion in Section 2 we proposed that certain kinds of the technological activities carried out by subsidiaries would be more likely than others to generate spillovers. More specifically, in hypothesis 1, we propose that 'competence creating' subsidiaries would be more likely to generate positive effects or spillovers than 'competence exploiting' or passive subsidiaries. This is because competence creating activities and the capacities associated with these activities, are more rarely present in firms in less advanced contexts and therefore are more likely to be of value to these firms.

The results in Columns 3 and 4 of Table 3 confirm this hypothesis. Only 'competence creating' subsidiaries, those involved in creative efforts in the host economy, have positive effects, in both cases when we use employment and capital shares. 'Competence exploiting' and passive subsidiaries have no effects on domestic firms. These results confirm hypotheses (1) and (3), but not hypothesis (2).

The absorptive capability model: Do these results hold for domestic firms with different absorptive capabilities?

We next explore whether our results hold for domestic firms with different absorptive capabilities or a technology gap. As already discussed, when results are not significant the spillovers literature often attributes this to the lack of absorptive capabilities in domestic firms. Since it is assumed that MNCs own and transfer superior technology, reasons for the absence of spillovers in host economies are typically seen as the inability of domestic firms to absorb the superior knowledge and skills that MNCs deliver to their subsidiaries We investigate whether this could be the reason for our non-significant results in the 'pipeline model', and for the 'competence exploiting' and passive subsidiaries. We use R&D

investment by domestic firms as an indicator of their absorptive capability. The interaction terms under the heading: *Absorptive capability of domestic firms and spillover effects* in Table 5 capture the combined effects of domestic firms' absorptive capability and FDI increases.

Table 5: Subsidiary driven model and Absorptive Capabilities

Independent variables	***Pipeline Model***		***Subsidiary Driven Model***	
	(1) FDI part in labour	(2) FDI part in capital	(3) FDI part in labour	(4) FDI part in capital
Spillover effects				
Δ FDI all types of subsidiaries	0.13	0.04		
	(0.64)	(0.36)		
Δ FDI competence creating subsidiaries			0.20	0.25
			(2.95)***	(3.44)***
Δ FDI competence exploiting subsidiaries			-0.045	0.05
			(-0.32)	(0.37)
Δ FDI technologically passive subsidiaries			0.14	0.11
			(0.92)	(1.8)*
Absorptive capability of domestic firms and spillover effects				
(Δ FDI all types of subsidiaries*R&D)	-0.09	-0.034		
	(-1.42)	(1.14)		
(Δ FDI competence creating subsidiaries* R&D domestic firms)			0.0040	0.0033
			(1.02)	(1.38)
(Δ FDI competence exploiting subsidiaries*R&D domestic firms)			-0.05	-0.055
			(-2.48)**	(-1.43)
(Δ FDI technologically passive subsidiaries*R&D domestic firms)			0.0070	-0.028
			(0.031)	(-1.27)
Control variables				
Age	-0.0018	-0.0018	-0.0030	-0.0030
	(-3.18)***	(-3.17)***	(-4.10)***	(-4.11)***
Age squared	0.000017	0.000017	0.0000284	0.000028
	(2.43)**	(2.43)**	(3.38)***	(3.36)***
Δ Concentration	-0.056	-0.0054	-0.067	-0.062
	(-0.58)	(-0.54)	(-0.62)	(-0.57)
Δ Imports	-0.074	-0.072	-0.1	-0.099
	(1.1.41)	(-1.39)	(-2.08)**	(-2.07)**
No. of observations	12,699	12,699	12,699	12,699
R-squared	0.013	0.013	0.022	0.022

1. The dependent variable is the change in TFP (expressed as a natural logarithm) of an Indian firm *i* at time *t*, derived from sector specific production functions estimated using the Levinsohn-Petrin approach. All specifications include a constant, year and industry fixed effect. Standard errors corrected for clustering for industry-year combinations, are reported in parentheses. * denotes significance at 10% level, ** at 5% level, *** at 1% level.
2. Columns (1) and (3) report the results obtained when using ΔFDI participation in labour at the 4-digit industry level and columns (2) and (4) report the results obtained when using ΔFDI participation in capital.
3. Competence creating subsidiaries are those subsidiaries that invest heavily in R&D and have highly skilled personnel, in both cases higher than the top quartile. Competence Exploiting are the subsidiaries that invest in

royalties and in imports of capital goods, and have highly skilled personnel, but do not invest in R&D. The rest are passive subsidiaries.

The results in Columns 1 and 2 are not significant indicating that, even allowing for differences in the absorptive capability of domestic firms spillovers, the 'pipeline model' does not provide significant results for India. Columns 3 and 4 on the other hand, which explore the 'Subsidiary Driven' model, show some significant results. First, we find, as before, that 'competence creating' subsidiaries, generate positive effects, and now it is confirmed that these effects are independent of the absorptive capacity of the domestic firms. Second, we find that the interaction term (Δ FDI competence exploiting subsidiaries*R&D domestic firms) is negative and significant for FDI participation in labour, indicating that 'competence exploiting' subsidiaries might be generating a negative effect on domestic firms with high absorptive capabilities.

So, we can confirm hypothesis 2, but with the caveat that it applies only to domestic firms with high absorptive capabilities: that is, the group of domestic firms that probably actually compete in products and for resources with foreign firms in the same markets. So, a market stealing effect emerges only for this group.

6. Conclusions

We have argued that the standard approach used to explore the possibility of FDI-related spillovers typically ignores the potential role of subsidiaries' heterogeneity in the process of spillovers generation. We discussed why this approach is inadequate in the light of recent evidence from the IB literature which suggests that subsidiaries are playing increasingly important roles in the process of knowledge creation, and even knowledge transfer within MNCs. We proposed then that subsidiaries should be at the centre of the spillover process. More specifically, drawing on the IB literature, we distinguished three types of subsidiaries: 'competence creating', 'competence exploiting' and 'passive'. We developed a set of hypotheses relating heterogeneity across subsidiary types in the host economy to the possibility of spillover effects. We hypothesised that competence creating subsidiaries were the most likely to generate positive effects because they were more likely to have valuable

resources relative to those available in industrialising countries. Competence exploiting subsidiaries, on the other hand, were hypothesised to have negative effects, because of the presence of market stealing effects. Finally, passive subsidiaries were not expected to have any effect.

Our results generally confirm our hypotheses: a) competence creating subsidiaries have a positive effect on the host economy, and this effect is independent of the level of absorptive capability of domestic firms; b) competence exploiting subsidiaries have a negative effect, but this effect only emerges for the more advanced domestic firms; and c) passive subsidiaries have no effect on the host economy's firms.

These results have important implications for our understanding of the process of spillovers in association with MNCs. In general, they suggest that the knowledge asset model of the MNC is no longer appropriate for analysing the significance of technology spillovers from FDI and that an alternative approach focused on the role of heterogeneous subsidiaries' own technological activities would be more useful. More specifically:

- first, they confirm our ideas about the potential differential effects of creative vs exploitative subsidiaries' activities in industrialising countries. In our view the first types of activities and associated capabilities are very often absent in firms in less advanced contexts, so subsidiaries undertaking these activities would be more likely to have a positive effect on domestic firms by their potential to leak resource that are more valuable in these contexts, i.e. resources that are otherwise not available (or less likely to be available) in less developed contexts.
- second, they confirm our idea that market stealing effects are more likely to emerge in association with the activity of subsidiaries oriented only to exploiting activities because, while they are at the same time more likely to be market seeking and to use the resources from their MNC to reduce costs beyond the levels faced by local firms, they also have less valuable resources to diffuse – firms in developing countries are used to exploiting technologies and new knowledge produced outside their systems;

- third, they highlight the importance of taking account of the possibility of passive subsidiaries in less advanced contexts. They are a relevant group - 50% of the Indian sample – and, although they are often ignored, they are shown to have no effect on the host economy. Thus, for research and policy purposes, it is important that they are distinguished from the other types of subsidiaries.

On the policy side, these results raise questions about the effectiveness of costly policies, often justified in terms of the potential spillovers, that seek simply to attract FDI regardless of the innovative activities that are likely to be undertaken by the subsidiaries that will be established. Our results would suggest that public funds should not been spent on trying to attract 'competence exploiting' or 'passive' subsidiaries. Instead, there should be greater inventiveness in the development of policy measures that influence the technological and other behaviour of subsidiaries, to promote their involvement in more creative activities in the host economy.

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